Report No. 74-05

IMPROVED LWL FUEL TABLET

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December 1973

Final Report for Period 5 October 1971 - 2 October 1972

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

US Army Land Warfare Laboratory
Aberdeen Proving Ground, MD 21005

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

Improved LWL Fuel Tablet

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final Report for Period 5 October 1971 - 2 October 1972

5. AUTHOR(S) *(First name, middle initial, last name)*

Frederick M. Drake

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1973	16	

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 07-S-72	Report No. 74-05
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT

Approved For Public Release; Distribution Unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	US Army Land Warfare Laboratory Aberdeen Proving Ground, MD 21005

13. ABSTRACT

The results of field evaluations of an acetal resin (Delrin) fuel tablet developed by the US Army Land Warfare Laboratory were generally favorable. The reports from the evaluating troop units in the field indicated problems in igniting the fuel and also an insufficient quantity of fuel.

Various combustible coatings and pyrotechnic-type starters were studied as means of improving ignition. These techniques were discarded for a number of reasons, including cost and excessive smoking. The tablet was then redesigned to provide a hole in the center of the tablet. Ignition at the tapered edges of this hole permitted rapid ignition and a build-up of heat output much faster than the original LWL Fuel Tablet. To provide more fuel the tablet was made thicker.

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AD-775464

INTRODUCTION

Under LWL Task No. 04-S-70, the US Army Land Warfare Laboratory developed a fuel tablet and devised a technique for making a stove out of an issue ration can. Evaluation of the "Improved Ration Heater and Fuel Tablet" as described in LWL Technical Memorandum No. 71-02 disclosed difficulties in igniting the fuel unit (two tablets) during cold and/or windy weather conditions. In some instances the field evaluators also expressed a need for more heat. The advantages of a stable, non-toxic, plastic fuel tablet over the current standard tablet were acknowledged. This task (07-S-72, "Improved LWL Fuel Tablet") was undertaken to correct the shortcomings noted in the evaluation.

DESCRIPTION

The fuel tablet is an acetal resin, a thermoplastic polymer, manufactured by the polymerization of formaldehyde. Table 1 gives some of the properties of Delrin.

TABLE 1. PROPERTIES OF DELRIN

	British Units	Metric Units
Specific Heat	0.35 BTU/Lb./°F.	0.35 kg. Cal./kg.°C.
Flame Temperature	19,000°F.	10,500°C.
Heating Valve	7,000 BTU/Lb.	1,764 kg. Cal./kg.
Self Ignition Temperature	707°F.	376°C.
Flash Ignition Temperature	613°F.	323°C.
Chemical Composition	Formaldehyde	
Chemical Resistance	Outstanding	
Sublimation	Does Not Sublimate	
Odor	Just Detectable	
Packaging Required	None	
Smoke	None	
Flame Color	Light Blue	

STUDY OF IGNITION TECHNIQUES

Since Delrin is a stable plastic and, according to the manufacturers, its physical properties cannot be altered by changes in production procedures, any improvement in ignition must be accomplished by coatings or pyrotechnic means, or perhaps by changing the configuration of the fuel tablet.

A small study was made of various combustible coatings. This included glues, epoxies, nitro-cellulose, and oxidants. They all improved ignition but they also smoked quite heavily and burned with a luminous orange flame, which would give a soldier's position away. The cost of the tablet would also have increased considerably, both from the cost of the additive coating and the extra operation required in manufacture.

Several pyrotechnic-type wire fuses were sealed in the outside edge of the tablets. When ignited, these burned too rapidly to ignite the fuel tablet. From a cost standpoint, these devices would have more than doubled the cost of the fuel tablet.

These studies were therefore discontinued and the investigation was directed toward improving ignition of the fuel tablet by a change in its physical configuration.

ANALYSIS OF CONFIGURATION

In its initial configuration, the disc-shaped fuel tablet, Figure 1, was molded with a thin tapered edge. The thin edge was easily ignited with a match, but the flame was too easily extinguished under windy conditions, particularly when held in the hand during this step and then transferred to the ration-can stove. It was difficult to light the fuel unit in the ration-can stove because of the narrow clearance between the edge of the tablet and the can.

After ignition, the flame had to propagate around the outside thinned edge of the tablet and burn inward to the center. Most of the heat generated was directed outward, away from the tablet and very little heat was available to initiate combustion of the main body of the fuel. Logically then, the best point to light the fuel tablet is in the center, allowing the heat from combustion to pass outward into adjacent material.

The first attempt to test this concept failed. Several tablets were modified by partially drilling out the center (3/4 inch diameter cut) and leaving a very thin section of material. Attempts to light this thin section were unsuccessful either due to the lack of sufficient oxygen at this point or to heat dissipation.

It was reasoned that an air hole, acting as a small chimney, was required to supply oxygen for ignition of the thinned edge. The tablets were modified as shown in Figure 2 and tested. Ignition was easily accomplished and it was possible to light the fuel unit by placing it in the ration-can stove, and simply dropping a lighted match into the ignition hole. The ration-can stove afforded some protection from the wind.

An added advantage of center ignition is the increased combustion rate of the fuel. When the fuel is ignited, it melts and eventually burns as a liquid. The time required to change from the solid to a liquid is $2\frac{1}{2}$ to 3 minutes. Optimum heat is given off when the fuel is burning as a liquid. The previous fuel unit with edge ignition required 5 to 6 minutes to convert to a liquid.

FIELD EVALUATION

The US Army Land Warfare Laboratory (USALWL) contracted for the fabrication of 100,000 fuel units for field evaluation. Over 50,000 fuel units have been distributed to various troop units, and sample evaluation questionnaires were provided. A typical cross-section of troops conducting these evaluations include: US Army, Alaska (5,000 tablets), 10th Special Forces Group, Fort Devens, Massachusetts (20,000 tablets), 1st Special Forces Group, Okinawa (3,000 tablets), US Army National Guard, Alaska (3,000 tablets), Eighth US Army, Korea (5,000 tablets), and the US Army Materiel Command Infantry Research and Developments Liaison Office (distributed to the Ranger Department, Fort Benning, Georgia, 1,000 tablets).

Evaluations were conducted under all types of weather and regional environments from the Arctic to the Tropics. Currently, Product Improvement Tests are being conducted by the US Army Test and Evaluation Command at the US Army Arctic Test Center, the US Army Tropic Test Center and the US Army Infantry Agency, Fort Benning, Georgia. The US Army Land Warfare Laboratory is supporting this test by providing 50,000 fuel units.

RESULTS

Tests of the USALWL Fuel Tablet were conducted in the Laboratory using a ration-can stove and the USALWL Grid. The tests were conducted with the standard Army canteen cup containing 8 ounces of water and with a ration can (larger size) containing 8 ounces of water. Typical results of these tests are shown in Figures 3 and 4.

Similar field tests were conducted at Aberdeen Proving Ground, Maryland by USALWL military personnel but in this case water at 0°C. was used in one series of tests and solid ice was used in another. Ambient conditions were mild with temperatures in the low seventies and approximately a five knot wind. The results of these tests are shown in Figures 5, 6, 7 and 8.

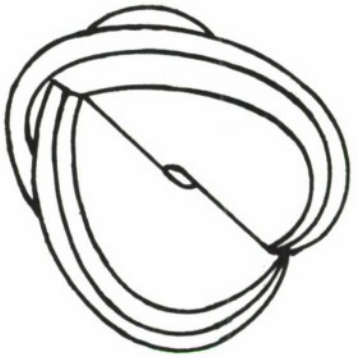
It can be seen from the graphs that dehydrated foods can be adequately reconstituted and hot beverages prepared. Canned rations were heated in from four to six minutes.

The results of the field evaluations, which were more subjective in nature, were in general very favorable. Two Commands, the US Army, Alaska and the US Army Southern Command, formally recommended Army adoption of the USALWL Fuel Tablet. Some unfavorable comments were received from various individuals participating in the field exercises. However, it was noted that most of these comments were elicited from individuals who had only used the fuel tablet three to five times, and usually under very adverse weather conditions. It is conjectured that (as with most new products), further dependence of the individual upon heating his food with the USALWL Fuel Tablet would have resulted in ways or methods of coping with the elements.

CONCLUSIONS

All objectives of the task were accomplished. The Improved USALWL Fuel Unit is easily ignited under adverse weather conditions and the total heat output has been increased by approximately 15%.

In addition, the combustion rate has been increased as a result of the center ignition point on the fuel unit.



ASSEMBLED TABLETS

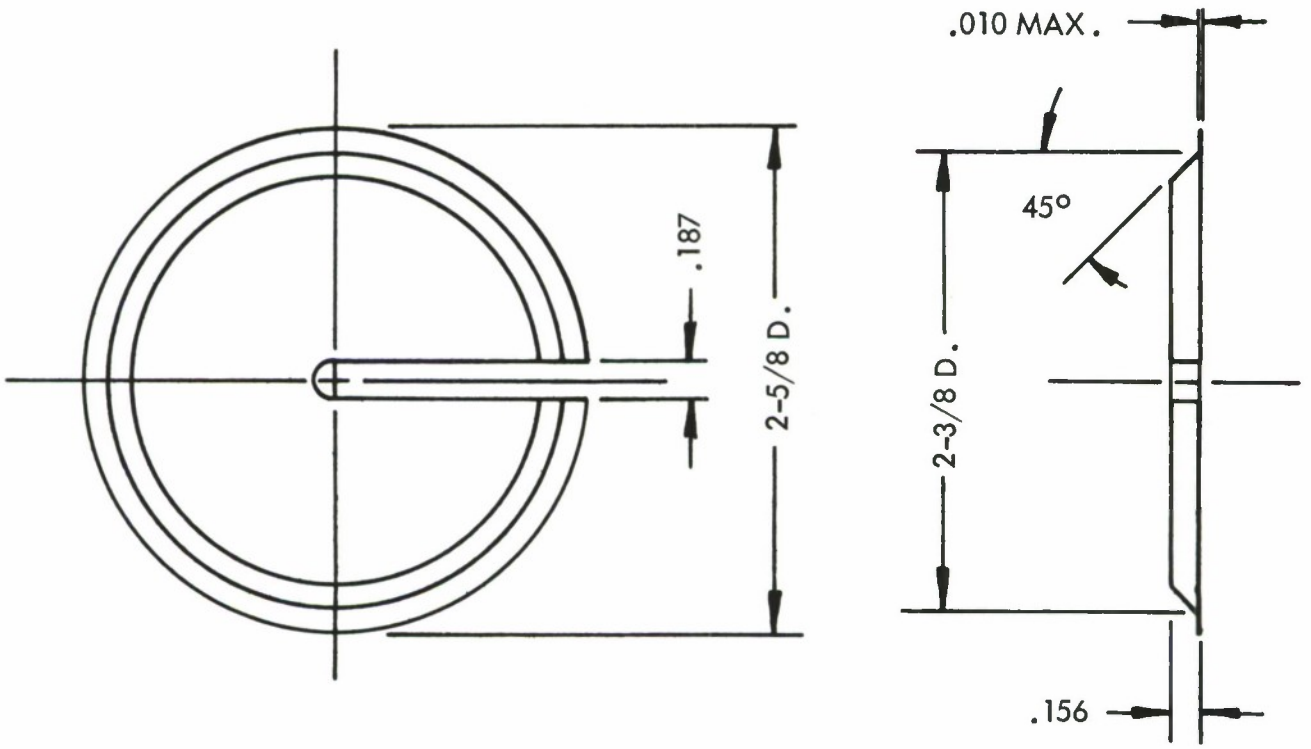
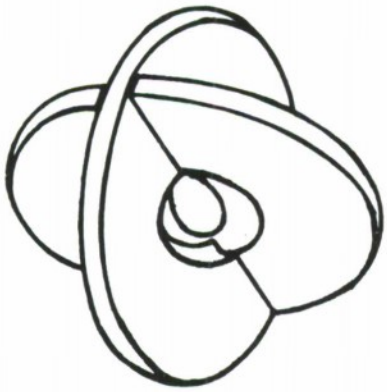


FIGURE 1. ORIGINAL FUEL TABLET



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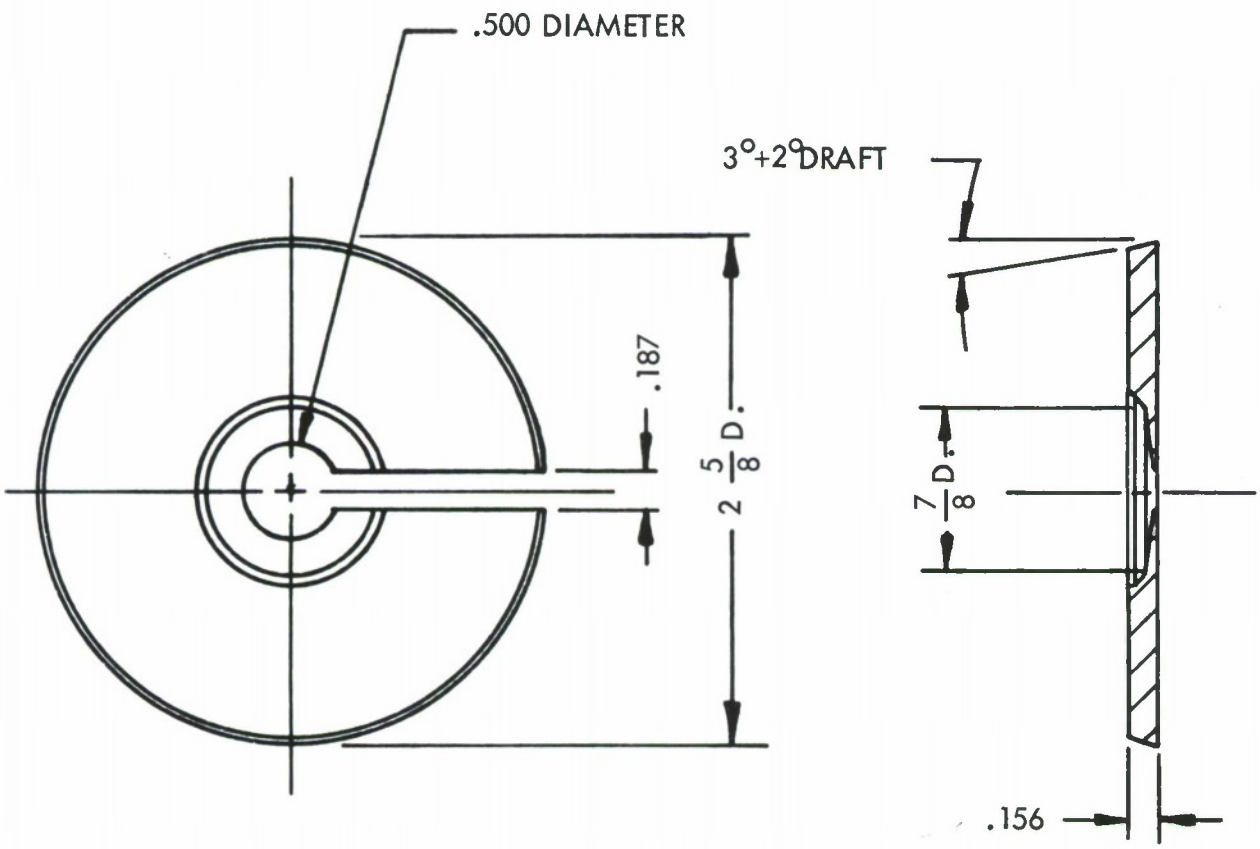


FIGURE 2. IMPROVED FUEL TABLET

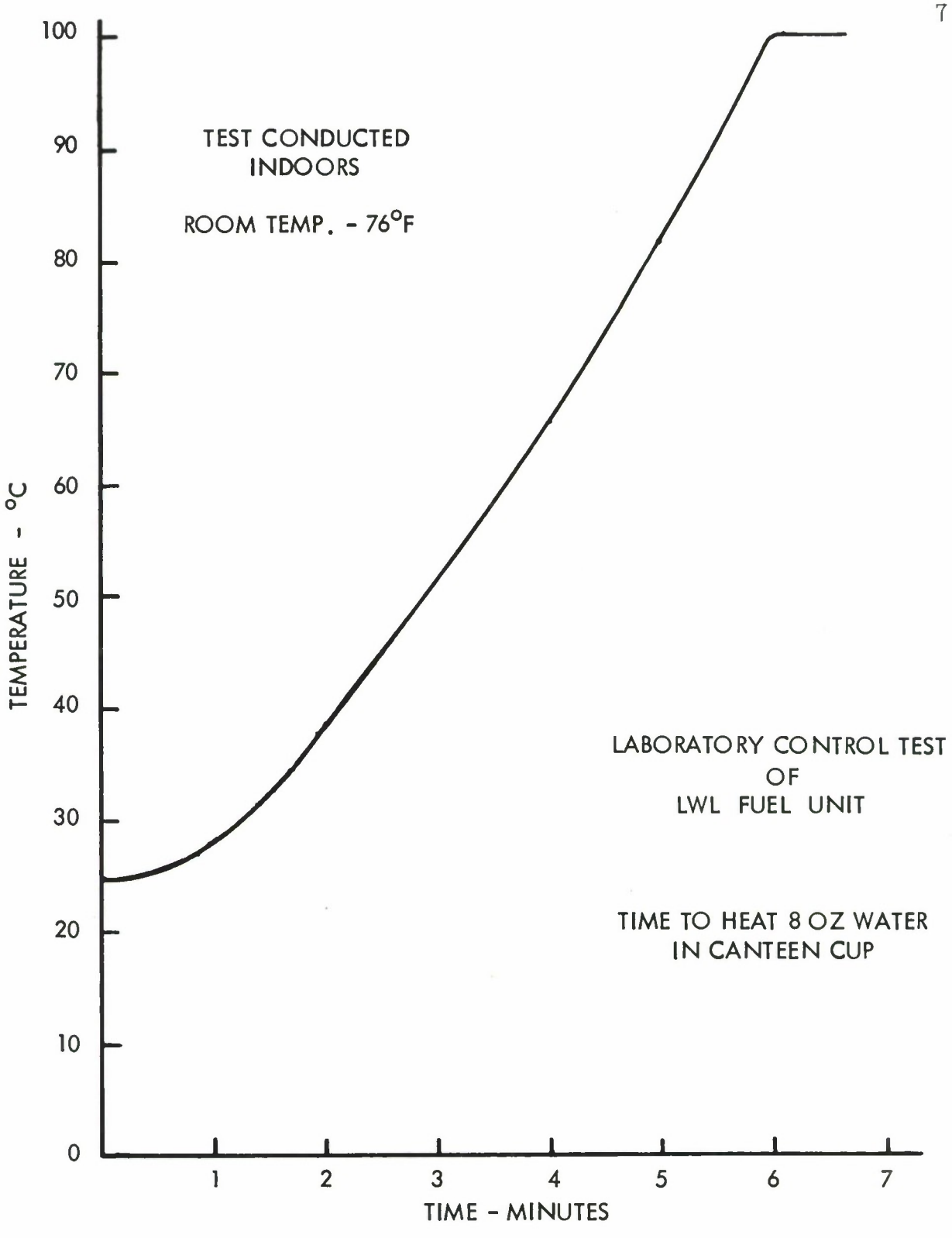


FIGURE 3. HEATING RATE

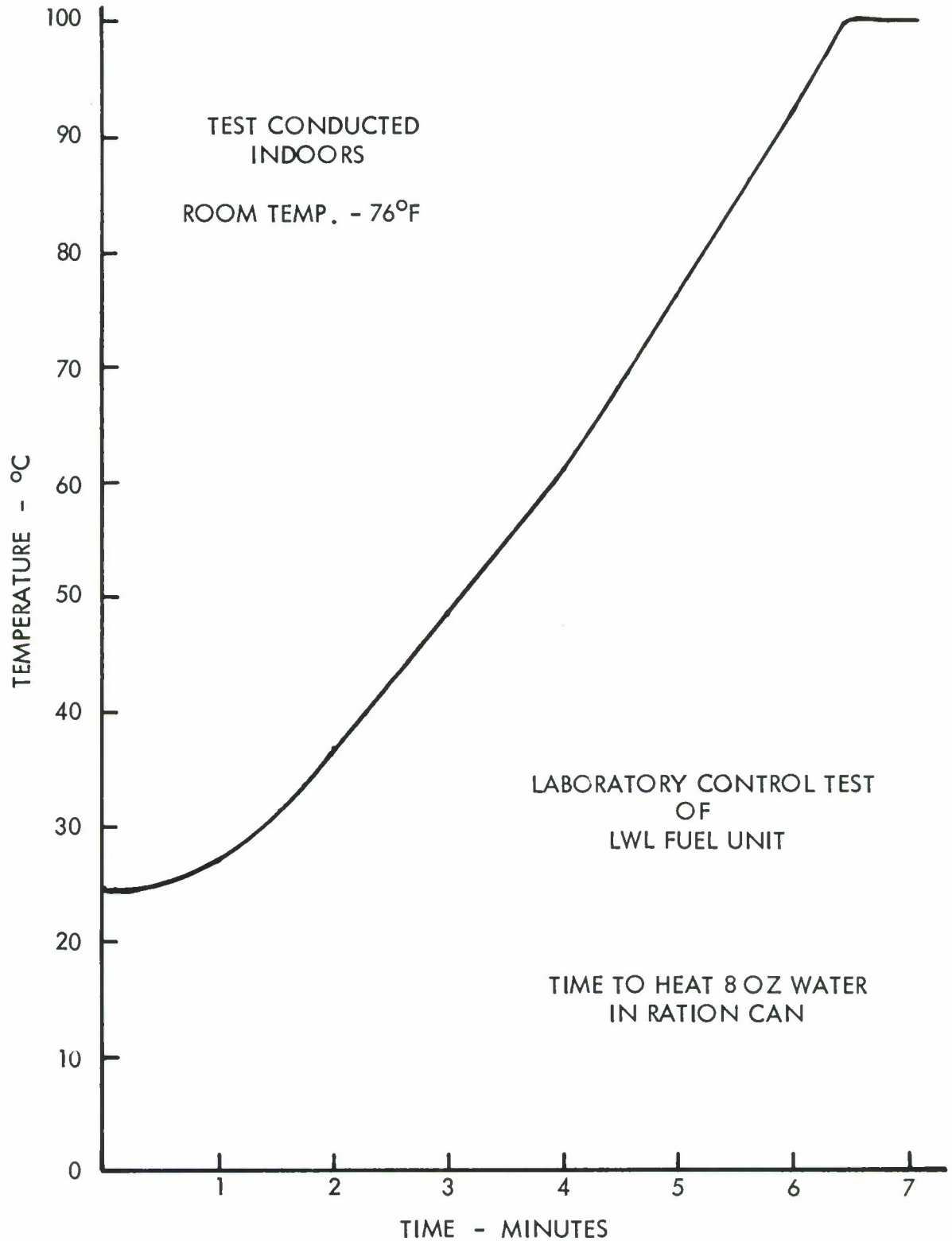
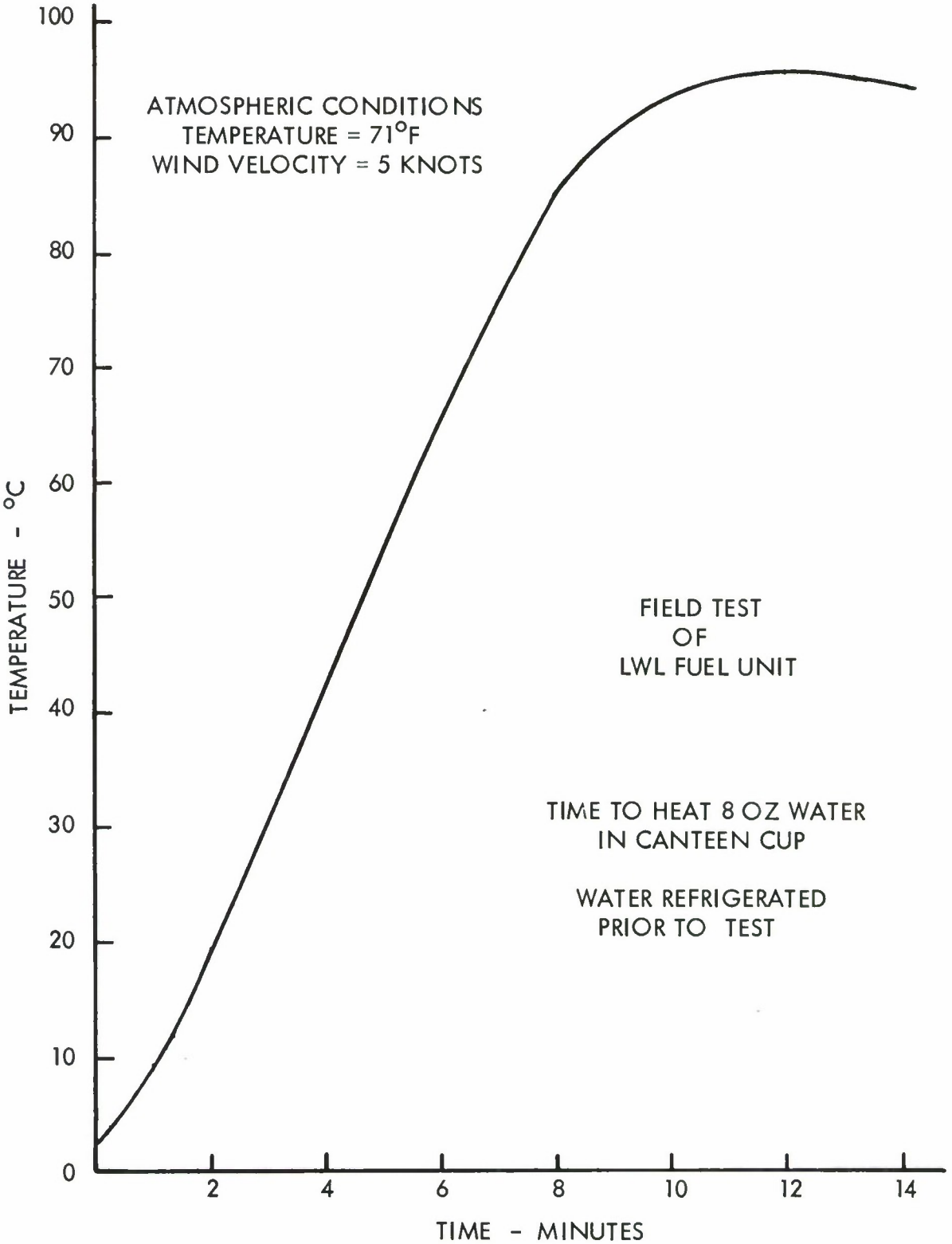


FIGURE 4. HEATING RATE



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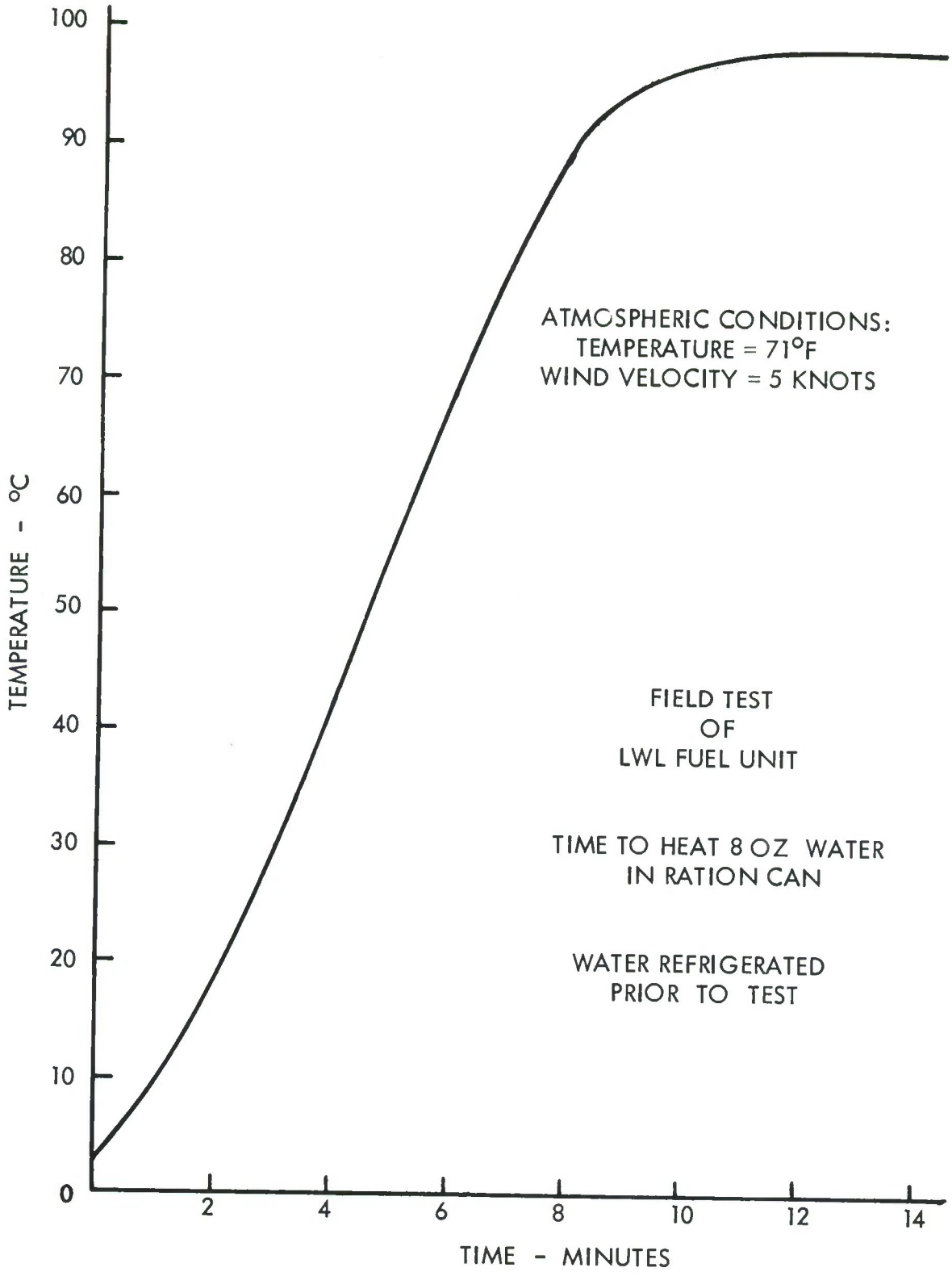

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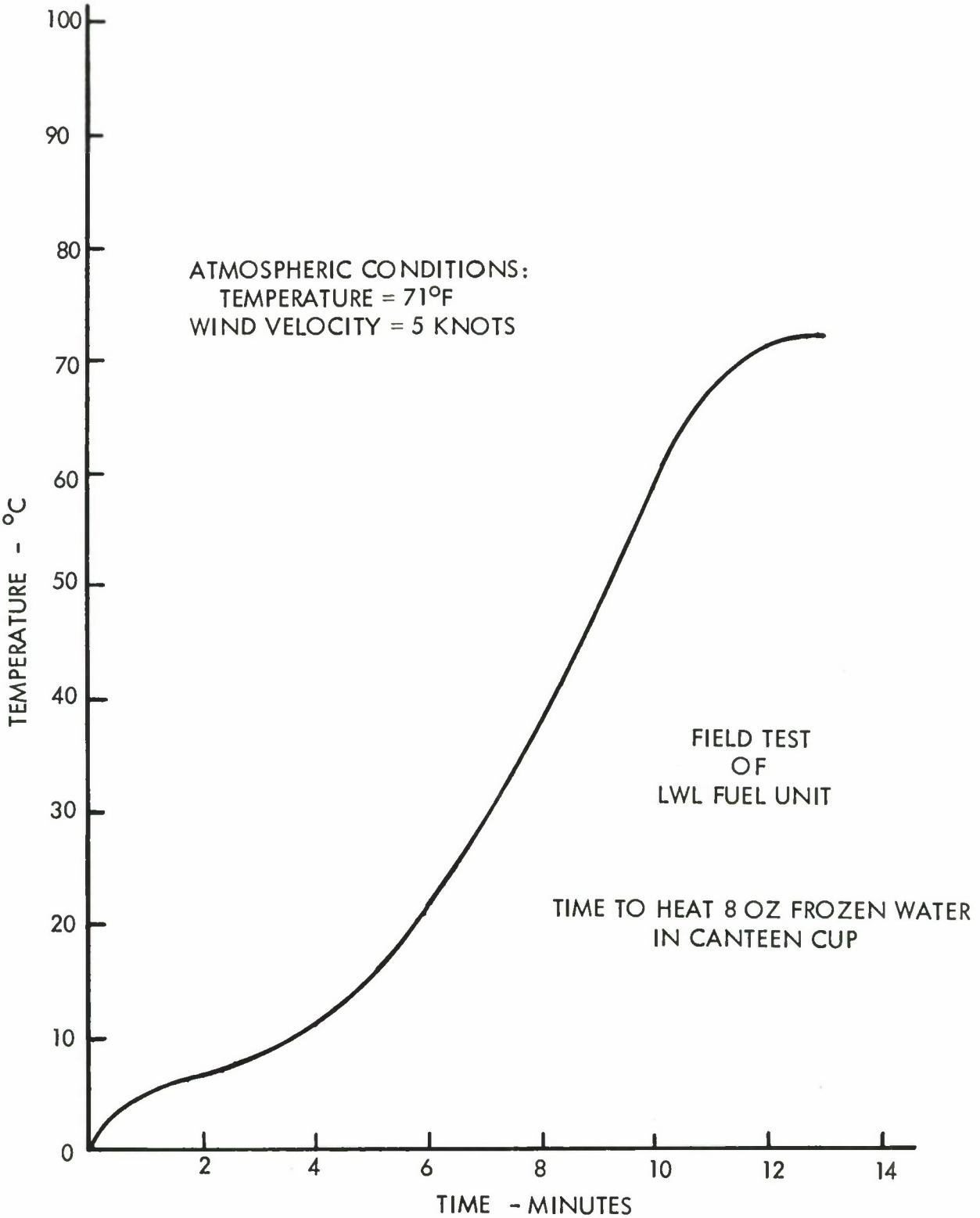

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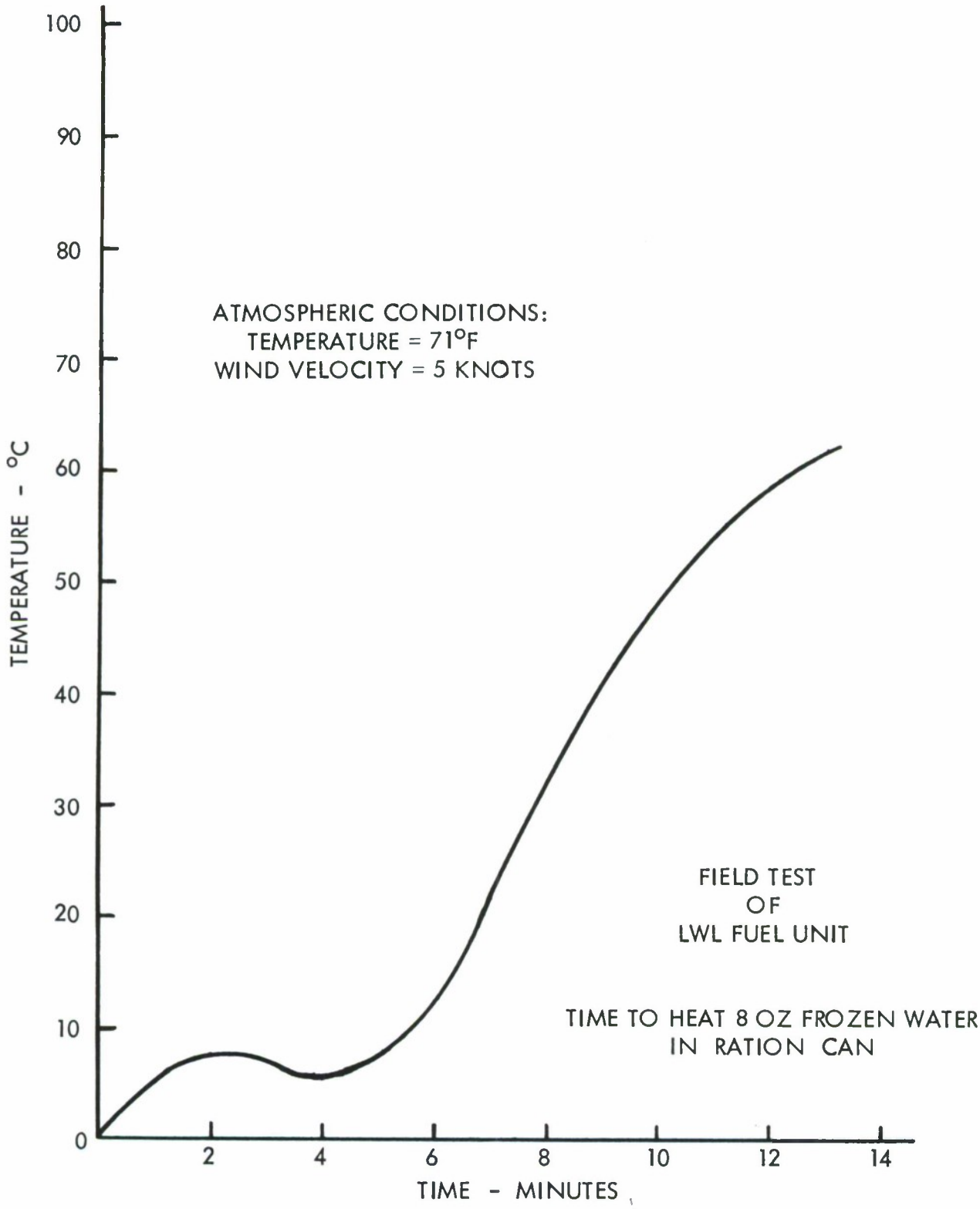

FIGURE 8. HEATING RATE

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